High temperature sensible heat storage for sodium receivers

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Concentrated Solar Power (CSP) is gaining great attention in the recent years because it is readily available, renewable and environment friendly. Development of high temperature thermal energy storage system plays a vital role in achieving more efficient and economical power plant. In this study, our focus is to develop inexpensive and efficient molten salt thermal storage system for modern high efficiency and high temperature power plants.

Introduction

Molten salts are widely preferred sensible heat storage media for large scale storage. Eutectic mixtures of nitrates salts with two tank configuration is commercially utilized in several CSP plants (Figure 1) [1]. Solar salt decomposes at higher temperatures [2] which makes it unsuitable for high temperature storage applications over 600 °C. Several researchers worked on developing different novel molten salts comprising of carbonates, chlorides and fluorides to serve the purpose of accumulating and storing thermal energy at high temperatures. In this research work, ternary mixture of chloride salts are selected as our base case scenario.

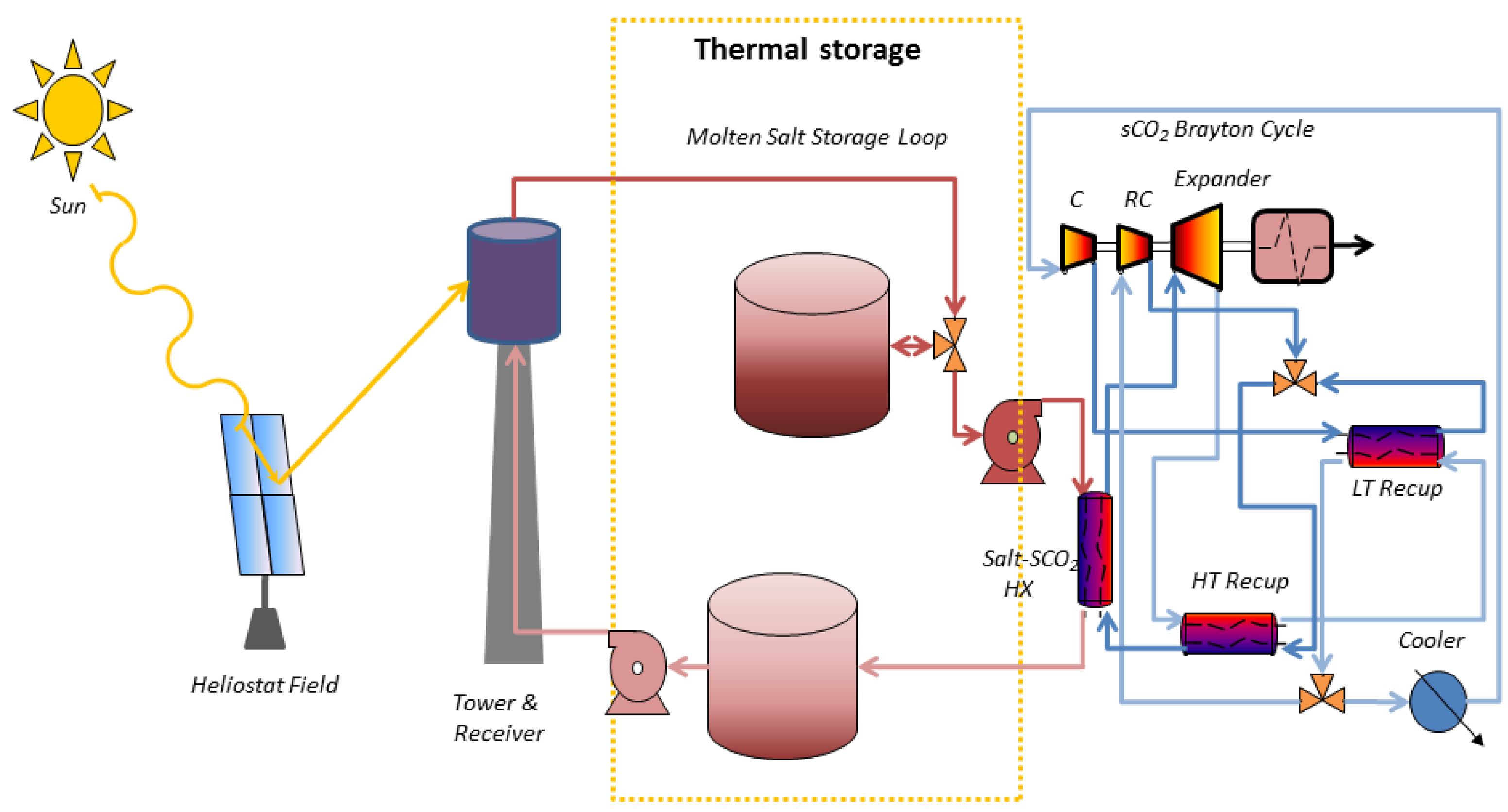

Figure 1: Schematic layout of two-tank CSP plant arrangement

Current activities at ANU

Development of high temperature storage salts

- Molten salt selection: Ternary eutectic composition of NaCl-KCl-MgCl2 system (24.5-20.5-55 wt%) has been considered as baseline case. This composition is selected based its high thermal stability and range of operating temperature (500-800ºC), and hence is compatibility with the current state-of-the-art high efficiency power cycles such as supercritical steam, s-CO2 etc.
- Off-eutectic molten salt with 10% variation in the proportions are also considered in the initial selection. Figure 2 shows phase diagram of ternary chloride mixture with eutectic and off eutectic regions, that will be investigated.

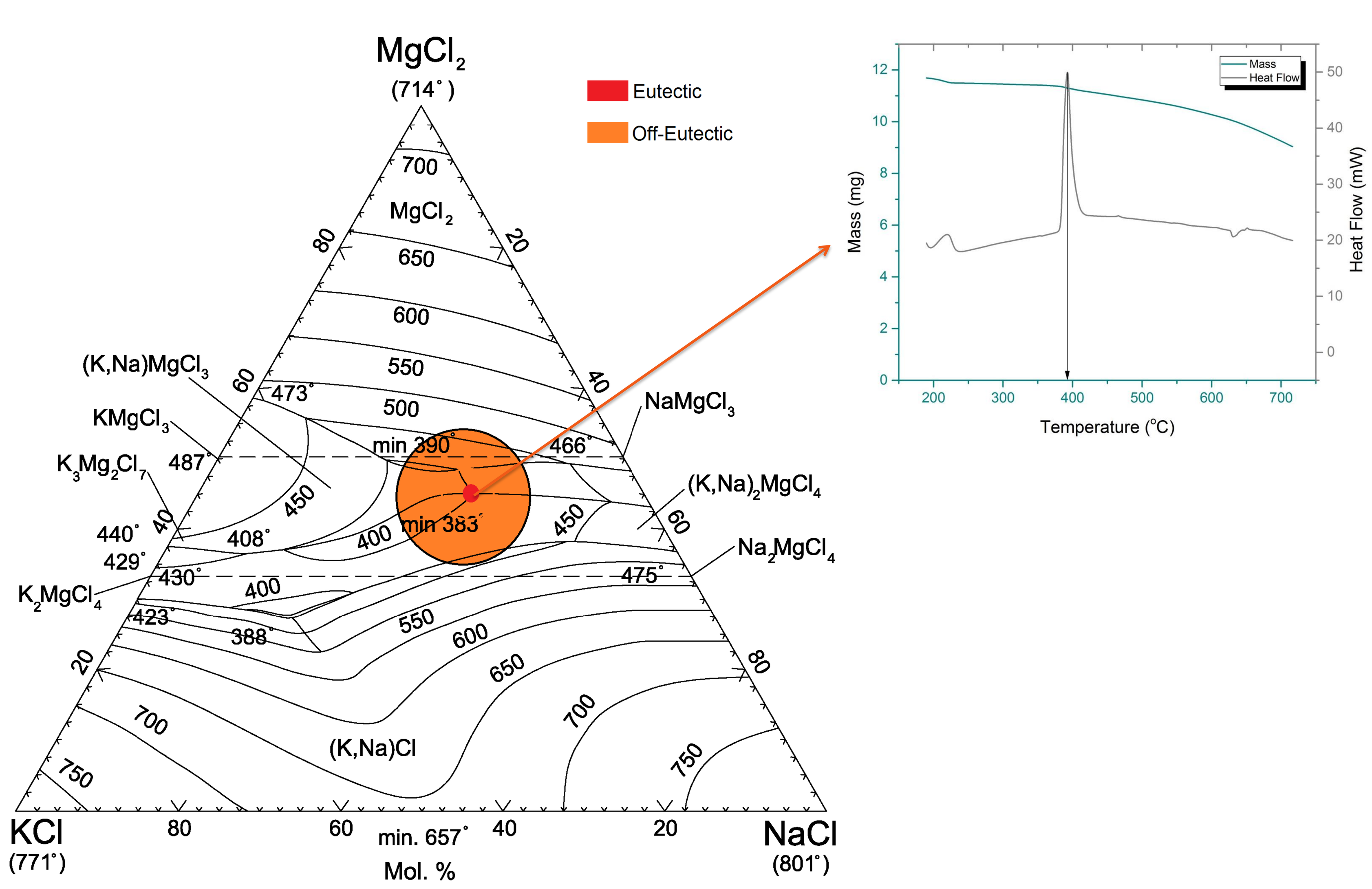

Figure 2: Ternary salt mixture Phase diagram with eutectic and off-eutectic marked.

Direct contact heat exchanger

Fluid flow and heat transfer simulations between liquid metal and molten salt in a novel direct contact heat exchanger (DCHE) is conducted (as shown in Figure 3) to achieve following benefits.

Advantages	Constrains
• Counter-flow DCHE has an thermal efficiency of 76% • No contact metal surfaces in the heat exchanger, which reduces cost and circumvents corrosion problems. Non reacting ceramic monolithic structures can be used as low pressure drop tubular multi-channel heat exchanger (Figure 3)	• Molten salts and liquid metals used in the DCHE should be inert and almost immiscible. This can be challenging for the highly reactive sodium • Density difference between two fluids should be significant

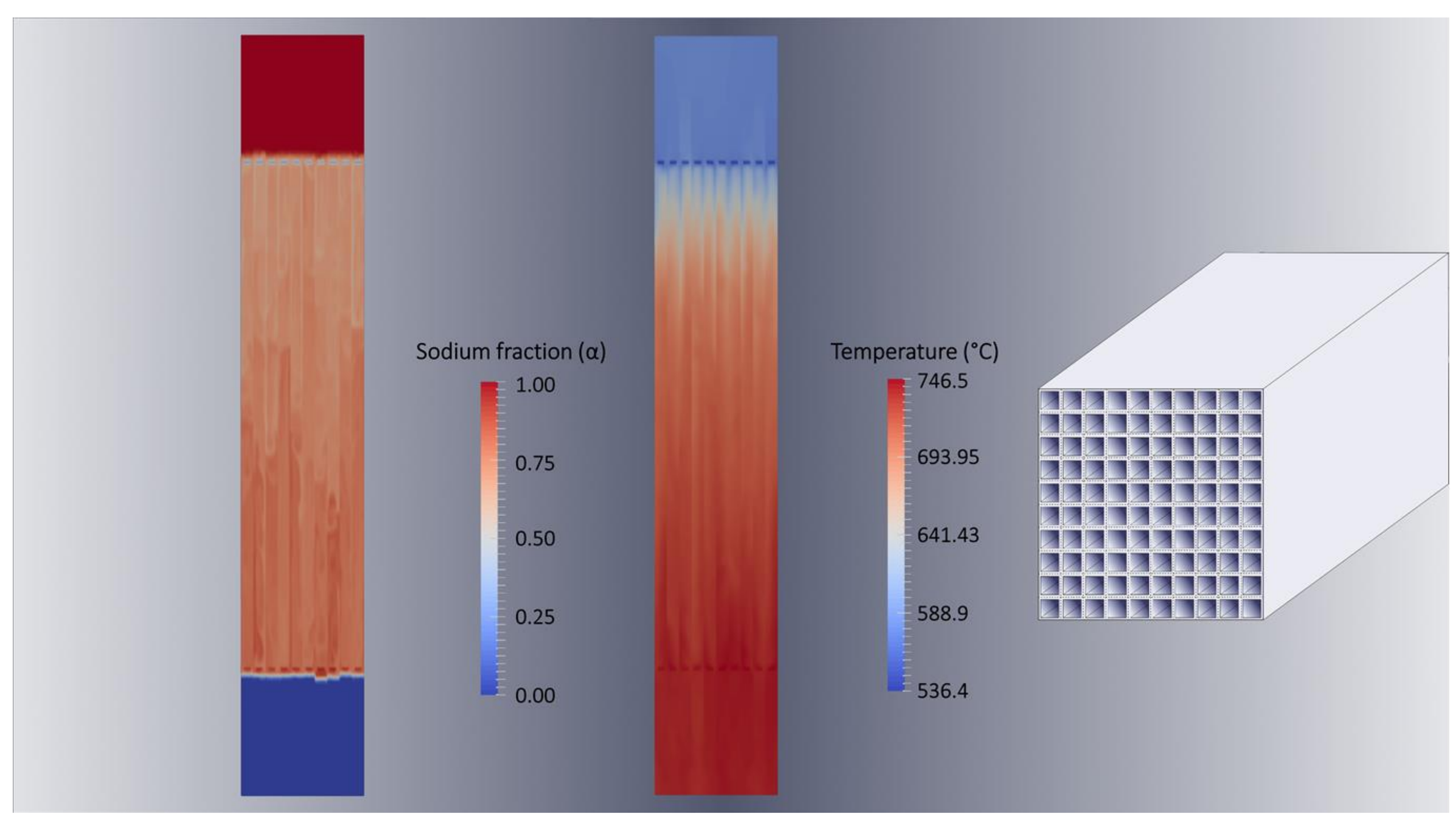

Figure 3: Simulation on direct contact heat exchanger

Future activities at ANU

- Increasing specific heat capacity of baseline salt with liquid metal and nanomaterial additives
- Reducing the freezing point of the molten salt with addition of hydroxides and low melting chlorides
- Compatibility of the salt with containment materials at high temperature is little known especially in terms of corrosion issues. Feasible containment material will be selected based on economical and technical feasibility.

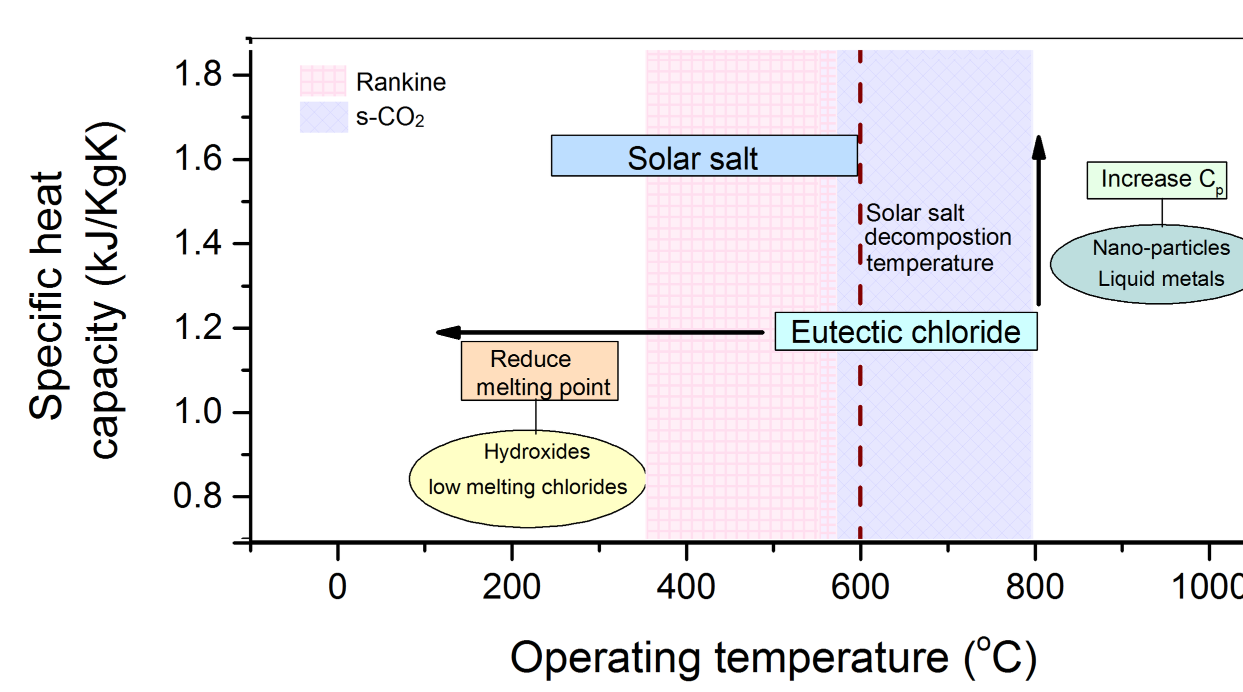

Figure 4: Improvement planned in baseline salt

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